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[illegible] German Democratic Republic

By P. [illegible], Jena and Berlin-Adlershof

1. Introduction

There are several towns in the territory of the German Democratic Republic being the birthplace of optical industry and research which today after decades of progress and development can look back on a long and famous tradition. Jena, however, has [illegible] and still is the center of the optical industries in the Republic. It was in this town that Carl Zeiss the ordinary mechanic of the University of Jena more than 110 years ago had started a small shop for the production of optical instruments. Nearly 100 years ago Carl Zeiss associated himself with Dr. Ernst Abbe, a mathematician, who solved the scientific problems the master mechanic was unable to tackle, thereby initiating the fruitful cooperation between science and industry which for many decades to come should establish the world-wide reputation of the Jena Works and which also laid the foundation of the VEB Carl Zeiss with its 18 000 workers becoming the most renowned factory in the German Democratic Republic and one of the greatest opto-finemechanical undertakings of the world.

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Industry and research in the field of optics is however not only domiciled in Jena but also in other places of our Republic, as e. g. in Rathenow, Görlitz, Dresden, Berlin, Potsdam, Leipzig, and Ilmenau.

2. Optical Industry

2.0 Preliminary Note

The great variety of products of the opto-finemechanical industry of the GDR - those turned out by the VEB Carl Zeiss Jena amounting to more than 4000 listed items - only permits of a survey which cannot be claimed to be exhaustive of the subject matter dealt with.

2.1 Raw Materials for Optics

Want of raw glass which on the strength of computations proved to be necessary for powerful optics induced Abbe in the eighties of the 19th century to contact Dr. Otto Schott whom he persuaded to come to Jena and to suggest the foundation of the Jenaer Glaswerk Schott & Genossen. The pioneer work of both investigators, which was directed to creating a catalogue with a large number of optical glasses, has been continued in the

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nationalised VEB Jenaer Glaswerk Schott & Genossen, Jena, who nowadays supply lanthanum-containing glasses of the latest type. In 1919 also the Jena Glass Works under the same terms became a part of the Carl-Zeiss-Foundation, the statutes of which operate with the force of law up to the present day.

In addition to the above subject of the production of optical glasses it might be of interest to mention that the VEB Carl Zeiss is also engaged in the growth of crystals from the solution and the melt for optical and other purposes (CaF_2 quarts and others).

2.2 Microscope Optics

The more than 110 year old tradition of the Zeiss Works laid the foundations of the latest developments of microscopes of the N-series (Ng for routine work; Nf for research work) with the large Universal Research Microscope Nu being the most perfect achievement in this line. By equipping the microscopes with supplementary devices all the classical as well as modern investigation methods ranging from observations in transmitted or incident light to investigations with variable phase-contrast, polarized or fluorescent light etc. can be carried out.

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The supplementaries include photomicrographic equipments, automatic exposure devices as well as a drawing equipment. Optics used in these instruments is by far superior to the apochromats developed by Abbe and use is nowadays not only made of plano-field achromats developed by the postmaster of computational optics in the GDR, Boegehold, but recently also of plano-apochromats which being computed for infinite focal intercept are also employed in incident light microscopes, as e. g. in "Neophot" and "Epityp". Moreover, particular attention received catoptric lens systems for microscopy.

A special development in the area of microscopy resulted in the construction of the Nuclear Track Measuring Microscope giving scientists the possibility of measuring the tracks of highly energetic nuclei in photographic emulsions with high precision. Microscopic equipments are however not only built by the Zeiss optical works in Jena but also by VEB Rathenower Optische Werke, as, for example, the polarisation working microscopes (Poladun VI for transmitted and incident light), the Microphot D 16 B with built-in special 35 mm camera, as well as the electrical integrator equipment Eltinor designed for use with the Poladun models.

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2.3 Photo and Cine Optics

The second field in which the Zeiss workshops gained world-wide reputation is that of photo-lenses; it is above all the well-known Tessar, the pioneering invention of Rudolph, which for decades has been copied all over the world upon expiration of the original patent. It is still manufactured in the Jena Works as 2.8/50 lens with its quality considerably improved. Besides, since 1945 several outstanding novel designs have been introduced, as e. g. the Flektogons 4/25 and 2.8/35 for 35 mm film, 4/50 and 2.8/65 for 60 x 60 mm^2 film, catoptric lens systems 4/500 for 35 mm film and 5.6/1000 for the medium format 60 x 60 mm^2. Thus the lens series now at our disposal are complete for focal lengths from 25 to 1000 mm for 35 mm films and from 50 to 1000 mm for medium format.

Further developments of Zeiss are: for aerial cameras the Pinatar 4/210 for 180 x 180 mm^2 image size, the recently designed Apo-Germinars in addition to the Apo-Tessars for reproduction purposes, the lenses 0.85/100 and 0.85/55 which are used on the Zeiss X-Ray Screen Image Cameras for radiophotography, and the Dokumars as taking and reproduction lenses for the

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well-known Zeiss Dokumator System, which comprises the Dokumator Photo Recorder, the Filing Folder, and the Dokumator Film Reader with requisite accessories.

In the field of vario-optics the Pantovar 2.8...32 developed by the Kamera- und Kinowerke Dresden is manufactured by the Zeiss optical works in Jena for 8 mm film cameras.

In addition to lenses of normal focal length f = 50 with the relative aperture 1:2 (Domigon as Gauss type) and with the relative aperture 1:2.8 both as Domiplan (Triplet) and as Primotar (Tessar type) the VEB Feinoptisches Werk Görlitz also manufactures short-focus lenses, as e. g. Domigon 3.5/30 and Primagon 4.5/35 as well as long-focus lenses, as e. g. the Tele-Megor up to 4.5/3000 (as tele-lens).

Cine projection lenses for 35 mm film have been produced in Jena for decades. About 10 years ago the Kipronars were replaced by Prokinars while these have recently been replaced by the Visionars with the relative aperture 1:1.6; it is for the first time that an excellent image quality throughout the whole field has been achieved

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with relative apertures as large as this. Today these lenses are supplied by VEB Rathenower Optische Werke, same as the anamorphic cylindrical lens attachment Rectimascop for expanding squeezed pictures in projection as well as spherical and aspherical concave mirrors for cine projectors.

Camera industry occupies an important position in the German Democratic Republic. Metropolis of camera production in the GDR is Dresden; well-known are the 35 mm single lens reflex cameras Exakta Varex, Praktina, Praktica, Pentacon, Pentina, the 35 mm camera Prakti, Penti for 18 x 24 mm^2 film, and the single lens reflex camera Praktisix for 60 x 60 mm^2 format, to name but a few. In addition to these a completely newly designed camera has been turned out by VEB Carl Zeiss Jena, viz. the Werra-Camera which is available in 5 different types with the automatic cameras Werramat and Werra V being the latest models of this series.

2.4 Opto-Physical Measuring Instruments

It was in the early 1890s that the Zeiss optical works expanded their manufacturing program by including opto-physical measuring instruments which rendered it possible to carry through chemical-analytical examinations by means of optical methods more suitable. Especially in this field

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rapid advances are made today towards the employment of recording and controlling large-type instruments by utilising the technical possibilities of electronics.

While originally only instruments were manufactured which should become the "classical" instruments for the determination of the refractive index, as e. g. the Abbe and Pulfrich Refractrometers, and later the Raleigh-Löwe-Haber-Interferometers, the today's program covers the whole field of the emission and absorption spectral analysis with the wavelength region being constantly extended to both sides.

In this conjunction mention must be made of the Quartz Spectrograph Q 24, the Three-Prism Spectrograph with four exchangeable camera equipments (particularly suited for Raman analysis) and the Plane Grating Spectrograph with 2 m focal length, which stood the test in analyzing purest substances and in solving special research tasks. It was not until a high-duty linear dividing machine had been developed that the construction of this spectrograph was made possible. Visual rapid analysis is afforded by the Industrial Spectroscope having a dispersion which corresponds to four 60° glass prisms. Flame emission and absorption analyses are likewise investigation methods

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employed. Feussner Spark Generators, Intermittent and Permanent Arc Producers serve as excitation instruments.

For evaluation of spectra use is made of the spectrum projector, which affords great convenience in operation, further of the Abbe-Comparator and the Rapid Photometer, the latter being now equipped with a compensation recorder. Extraordinarily high fidelity of records is warranted by the new Photoelectric Recording Photometer Lirepho 2.

Employment of filter photometers (Pulfrich Photometer used in conjunction with photoelectric auxiliary equipment, Leukometer, UV-Photometer and others) opened a way to the absorption spectrum analysis with its border fields of fluorescence and turbidity measurements, remission and reflection measurements. Outstanding in recent developments is the All-Automatic Infrared-Spectrophotometer UR 10 with a spectral region from 2 to 25 μ (5000 to 400 cm^{-1}) covered by lithium fluoride, rocksalt and potassium bromide prisms, which permit of being automatically changed. By means of a program selector any wavelength region may be picked out and recorded. The applicability of the instrument is considerably increased by numerous accessories. -
As unit assembly the non-recording Universal Spectrophotometer

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permits of being adapted to all routine and research tasks that may occur in a spectral region covering the range from the ultraviolet to the near infrared. The new high-duty Mirror Monochromator combining a maximum of conveniences in operation with a large field of application (200 to 50 000 mμ) and offering the possibility of optionally choosing prisms or diffraction gratings will soon find the high approval of chemists, physicists, biochemists and other research workers.

A few remarks may be added on the Konimeter, as well as the Schlieren Apparatus. Being equipped with checking and evaluating devices the Konimeter is used for measuring the dust content of the air in industrial centers and works, as well as in large cities, while the Schlieren Apparatus permitting of the Toepler Schlieren method to be employed serves e. g. for investigations of high-molecular substances.

2.5 Astronomical Instruments

Towards the end of the 19th century the Zeiss optical works in Jena started producing astronomical instruments. These large -type instruments were in each case made to special order in compliance with the individual wishes

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of the customers. Newly developed instruments turned out by Zeiss are the Astrograph 400/1600 as well as the Double Astrograph 400/2000. Coudé Refractors 150/2250 and 200/3000 have been developed for use in smaller observatories of universities. Besides these refractors it was in recent years primarily the reflector telescopes based on the Schmidt mirror system that met with a favourable reception, such as, for example, the Schmidt Reflector Telescope 600/900/1800; best known among the Zeiss telescopes is the Schmidt Reflector Telescope 800/1200/2400 supplied to the Hamburg-Bergedorf Observatory. VEB Carl Zeiss Jena also supplied the largest reflector telescope of Europe, the 2-meter Schmidt mirror complete with all accessories. It has been established in Tautenburg near Jena in the Karl-Schwarzschild-Observatory of the German Academy of Sciences and is available to all German astronomers for individual and joint researches.

2.6 Photogrammetric Instruments

On the turn of the century the photogrammetric department grew out of the measuring instruments department of the Zeiss-Works as a special branch; in more than 60 years of its existence this field has become one of the most important of instrument manufacture in Jena. In addition to the Stereoplanigraph used for decades an advanced

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design of the Stereoautograph has been brought out in recent years. Terrestrial photographs which are plotted in the Stereoautograph, may be produced by the Phototheodolite 19/1318.

The Aerial Survey Camera MRB 21/1818 fitted with the above-mentioned Pinatar 4/210 is a fully automatic film camera for aero-photogrammetric survey work. The plotting of photographs reduced in reduction printers can be carried out in the "Multiplex", a stereo mapping equipment of 2nd order, which is now supplied as ultra-wide angle equipment in addition to the former models of the normal and wide angle Multiplex instruments. The Stereometrograph, which operates by the well-established "classical" method of strict spatial reproduction of the exposure process, represents the latest design of 2nd order stereo-plotters. The corresponding measuring-rays from the model-point to the image-point are produced by means of mechanical precision-guides. For evaluation Zeiss supplies a newly developed instrument, the Coordimeter, permitting not only the automatic recording of machine coordinates of photogrammetric evaluating instruments but which also carries out program-controlled calculations.

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2.7 Surveying Instruments

Scarcely a decade had passed after photogrammetric instruments had been included in their production program when the Zeiss Works started manufacturing instruments for surveying. The production program covering a wide scale of surveying instruments includes e. g. the well-known Reducing Tacheometers "Redta 002" and "Dahlta 020", which are highly economic in operation, as well as a small-type Theodolite 020. In this conjunction special mention may be made of the Seconds Theodolite 010 with an elongated mirror-lens telescope (Cassegrain) having a free objective aperture of 53 mm. diameter and a magnification of 31x (mean square directional error in one set of measurements $\pm 1.3''$ ($\pm 4^{cc}$)). It is especially suited for triangulation work up to the second order and, with Invar base subtense staff and target signal equipment, for precision traversing. Without micrometer the Tacheometer Theodolite 020 with a telescope magnification of 25x permits of directly reading the values with the mean square directional error not exceeding $\pm 5''$ (15^{cc}). It is equipped with a device for repetition measurements which ensures special ease in operation. Its vertical index is automatically leveled.

A few additional remarks on levels remain to be made.

The Precision Level "Ni 004" has been designed for leveling

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work of 1st and 2nd order, its mean square error per 1 km double leveling amounting to ±0.4 mm. Mention may still be made of the level "Koni 007" with automatically leveled sighting line; it is optimally usable for ordinary leveling work by estimating staff intervals (±2...3 mm for 1 km double leveling) or for precision leveling by using a parallel plate micrometer (±0.5...0.8 mm).

2.8 Opto-Ophthalmological Instruments

Few years later the Zeiss optical works also included in their manufacturing program spectacle lenses, of which the Zeiss Punktal lenses have gained high reputation, multifocal lenses and last not least ophthalmological instruments. Besides the well-known instruments, such as the Coincidence-Refractionometer and the electrical Hand-Ophthalmoskope it is primarily the retinal camera "Retinophot" that has gained special importance. The optical elements of this camera as well as the light source (high pressure Xenon lamp) are so adjusted that a diameter of the pupil of only 5.5 mm proves to be sufficient for perfect exposures. Further, mention be made of the Schiötz Standard Tonometer, which though not an optical device, is a new important ophthalmological instrument for the mechanical measurement of the interocular pressure of the eye.

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3. Institutes

The great traditions of the optical industries resident in the territory of the German Democratic Republic are the background for the rather intensive research activities in the institutes of our academies and universities.

3.1 The Institute of Optics and Spectroscopy is affiliated to the Society for Scientific Research of the German Academy of Sciences in Berlin. In 1948 it was founded by E. Lau as a small laboratory from which developed the two large domains of science with more than 100 cooperators (including 32 scientists) doing research work in 18 special laboratories. The headship is entrusted to R. Ritschl and P. Görlich. The task complex includes researches in the following fields: theoretical optics, interference optics, geometrical, atmospherical, and physiological optics, microscopy, contrast transmission theory, scientific photography, spectroscopy of atoms and molecules, optical media.

An interesting modification of the conventional light microscope whose resolving power cannot be extended beyond a certain limit is the so-called double microscope developed by E. Lau. By means of a rotating ground-glass

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obtains an effective enlargement of the exit pupil of the microscope. In this way entoptic phenomena in the eye and similar phenomena in the optics of the instrument are practically eliminated while the exploitation and utilization of the optimum theoretical efficiency of the objectives is highly facilitated. Higher magnifications combined with a noticeable gain in information are practically possible.

Fundamentally new investigations into double and multi-beam interferences in the field of interference optics resulted in a new theory of double-beam interference (visibility and position of fringes, aperture ratios, etc). Comparative studies on interference microscopes led to new suggestions for interference microscopes in transmitted and incident light which allowed exact quantitative measurements to be carried through; outstanding in this series of microscopes is an incident light interference microscope without depiction of the usual reference surface.

Special attention was given by the institute to two-dimensional photometry. The variety of these methods was subsumed under "equidensitometry". In the case of photographic pictures curves of equal density (equidensities)

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corresponding to the isophots on the object are obtained in different manners; photographic, photochemical and electronic automatic techniques have been developed which may with advantage be used for remarkably enhancing the measuring accuracy of physical and technical working procedures. Equidensity curves have gained importance in measurements both of displacements of interference fringes and deflections within the spectral lines, in photometric and sensitometric investigations, in dosimetry, in obtaining isophots, in photoelasticity and in solving many other problems. On the basis of the screen technique a new method could be developed for a complete two-dimensional photometry of photographic pictures.

A novel type of photometry used already with advantage for spectra of stars was introduced by the interference-microscopical evaluation of the density relief of the photographic plate.

In the field of raster optics (Moire-fringes) research workers of the institute developed the technique of dupligrammetry, which e. g. extremely facilitates the evaluating of interference patterns of objective testers but also lends itself favorably for other purposes.

In the province of scientific photography new techniques have been developed concerning the increase in sensitivity,

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discernibility and contrast control. Here use is made of colored masks and emulsions without toe and switch.

As regards atmospheric optics investigations are being made into the effect of aerosol on the degree of polarization of celestial light as well as studies on the IR-transmissivity of the atmosphere.

The task complex of the research work includes: studies on accommodation, near-astigmatism, binocular vision and its disturbances, vision in traffic, chromatic aberration of the eye and color perception, further the development both of instruments and tests for the examination of the eye as well as quick and routine examinations in factories.

In connection with studies on the correction of eye defects by means of optical aids Lau-Jaeckel-Richter developed and tested a spectacle lens with a refractive effect continuously changing over a range of 1.5, 2 and 3 D. This glass is a multi-focal lens with continuously increasing refractive power, a valuable visual aid for presbyopes, which proved its efficiency in extensive series of tests.

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The institute exhibited a particular activity in the province of spectroscopy. The wide range of investigation covers not only scientific spectroscopy but also studies on the application of spectroscopy of all wavelengths for routine examinations, especially in industrial quarters. Spectroscopical investigations into energy states of atoms have been and are still carried through. Objects of the researches are the transfer of energy through collisions of 2nd kind, metastable excitation steps and its lifetimes, self-absorption, isotope effects as well as hyperfine structure. Moreover, research work is done in the field of vacuum and molecular spectroscopy, as e. g. investigations of infrared spectra of organic molecules, assignment of bands, intensity measurements of infrared bands, isotope effects produced by substitution of hydrogen, nitrogen and other isotopes. The working scope of the institute further includes spectroscopical studies on the behavior of adsorbed pigment molecules (photographic sensitizers and desensitizers) as well as analyses of luminescence spectra of pigment molecules.

In furtherance of the application of spectroscopy for routine work the institute performs investigations of light sources, excitation modes for the emission spectrum analysis, time-resolved spectra, effect of buffers as well

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as statistical studies on the accuracy of emission analysis. Moreover, attention is given to the development of methods and instruments as employed in Raman spectroscopy of liquids and gases as well as to the construction of Raman burners. Due to the great importance to be attached to optical media spectroscopical examinations and experiments are also carried out with the aim of producing such materials with as high a degree of purity as possible.

By personal union (R. Ritschl) with the Ist Physical Institute of the Humboldt University Berlin several spectroscopical problems dealt with in the Institute of Optics and Spectroscopy are also object of investigations in the Physical Institute. Spectroscopy in the far infrared and the examination of organophosphors may be regarded as a speciality of the Physical Institute.

To cite but one example from the vast number of publications issued by the institute mention be made of the first comprehensive reference book "ABC of Optics" which on about 1000 pages contains 10 000 partly rather detailed contributions made by a great number of distinguished scientists; the text is illustrated by 1600 figures as well as black and white and colored plates.

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3.2 Part of the task complex of the Institute of Instrument Manufacture (directorship H. Jancke), which is likewise affiliated to the Society for Scientific Research of the German Academy of Sciences in Berlin, is to develop special instruments for the application of optical methods in analysis technics.

3.3 Universities

Among the universities of the German Democratic Republic it is in the first place the Institute of Applied Optics (directorship K. Kühne) of the Friedrich Schiller University Jena that is concerned with the problems of interferometric testing of objectives, interferometric measurement of lengths and molecular-optical investigations of glasses. At the Institute of Mathematics of the Karl Marx University Leipzig, J. Focke lectures on geometrical optics (theory of image errors).

Other research quarters dealing with physiologic optics and ophthalmological optics are affiliated to the ophthalmic hospitals of the Medical Academies in Magdeburg, Erfurt, and Dresden.

Spectroscopic teams are doing research work at the Physical Institute of the Friedrich Schiller University

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Jena (directorship W. Schuetz) in the area of molecular Raman spectroscopy and at the Physico-Chemical Institute of the same university (directorship H. Dunken) in the field of molecular spectroscopy, especially in the infrared.

3.4 High Schools

Research in optics receives strong support by the Institute of Theoretical Physics of the Pedagogic High School Potsdam (directorship Picht). Their main fields of investigation are in particular the diffraction theory and the theory of total reflection.

Thorough investigations into infrared and Raman spectroscopy are carried out by a spectroscopic group (under A. Simon) at the Technical University Dresden.

3.5 Technical Schools

Jena is the home of a technical school specialized in ophthalmic optics.

4. Scientific Conferences and Commissions

4.1 Conferences on optics are held by the Physical Society of the German Democratic Republic at Jena almost every

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3 years. In 1954 the conference was concerned with "Optics"; in 1958 the subject dealt with was "Optics of all Wavelengths", while in 1960 it was called more precisely "Optics and Spectroscopy of all Wavelengths. The next conference is scheduled to take place in 1963.

Scientists from many countries attended these conferences and gave them an international flavour (cf. proceedings of the conferences).

In addition to these large-scale meetings courses are regularly being held on the application of microscope equipments, measuring instruments, photogrammetric and fine-limit measuring instruments, which are also attended by an international audience. One of the sections within the Physical Society of the GDR is the spectroscopy section under the headship of Ritschl. This section plays an important part in so far as not only whole industries (as e. g. Elektrochemisches Kombinat Bitterfeld, Farbwerke Wolfen, Gummikombinat Kowalit, Buna-Werke Schkopau and others) employing spectroscopy for routine work, but also institutes (as e. g. Institut für Reinststoffe Dresden, Zentralinstitut für Kernforschung Rossendorf, Institut für Physikalische Stofftrennung Leipzig and others) are concerned with individual problems of scientific

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spectroscopy and are accordingly interested in an exchange of scientific results and experiences.

4.2 The Commission for Spectroscopy of the German Academy of Sciences (under the headship of P. Görlich) grew out of the Infrared Commission constituted in 1955. It is the aim of this commission to stimulate and coordinate researches in the field of molecule structure and molecule properties as well as researches in the province of spectrum analyses with physical methods. Besides, it is incumbent on the Commission to establish and foster relations with scientists abroad and to maintain a rapid information service in the fields of infrared, Raman and high-frequency spectroscopy.

Acknowledgment

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